Subsurface Flows With Advancing Solar Cycle Using Dense-Pack Ring Diagram Analyses

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Large-scale horizontal flows within the upper convection zone of the sun are analyzed using the helioseismic technique of ring-diagram analysis applied to data from SOI-MDI. We map the velocity field over a substantial fraction of the solar disk by carrying out local inversion analyses over a Dense-Pack mosaic of many overlapping sites. There are substantial changes in subsurface flows at any given site from one day to the next that appear to be of solar origin. Such mosaics are processed almost daily for at least two solar rotations during each of the MDI Dynamics Campaigns from 1996 through 1999.

We find that longitudinally-averaged zonal velocity possess bands of fast and slow flow. As the solar cycle progresses, the latitudes at which the fast bands occur migrate towards the equator and vary in their flow amplitudes. These bands are not symmetric about the solar equator, and their asymmetry changes with time. The average meridional flow for the years 1996 to 1998 is primarily poleward, reaching maxima in the two hemispheres at the latitudes at which the zonal fast belts occur. The latitudes of maximal meridional flow drift equatorward in time much as the zonal fast belts. However, in 1999, the meridional circulation in the northern hemisphere develops a two-celled structure with latitude, whereas in the southern hemisphere it remains single celled.